

7-12-00

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UTILITY PATENT APPLICATION TRANSMITTAL	Attorney Docket No. ACT-121	Total Pages 18+7
	First Named Inventor DAN A STEINBERG	
	Title OPEN FACE OPTICAL FIBER ARRAY FOR COUPLING TO INTEGRATED OPTIC WAVEGUIDES AND OPTOELECTRONIC SUBMOUNTS	

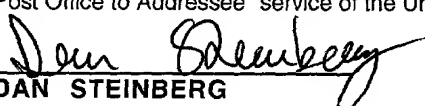
1c808 U.S. PTO

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APPLICATION ELEMENTS	ACCOMPANYING APPLICATION PARTS
1. <input checked="" type="checkbox"/> Fee Transmittal Form (two copies)	8. <input type="checkbox"/> Assignment cover sheet and document(s)
2. <input checked="" type="checkbox"/> Specification Total Pages: [18]	9. <input checked="" type="checkbox"/> Power of Attorney by Assignee [] with CFR 3.73(b) statement
3. <input checked="" type="checkbox"/> Drawing(s) Total Sheets: [7]	10. <input type="checkbox"/> English Translation Document
4. <input checked="" type="checkbox"/> Oath or Declaration Total Pages: [1]	11. <input checked="" type="checkbox"/> IDS/PTO-1449 <input checked="" type="checkbox"/> with copies of cited references
a. <input type="checkbox"/> Newly executed (original or copy)	12. <input type="checkbox"/> Preliminary Amendment
b. <input type="checkbox"/> Copy from a prior application 1.63(d) (complete Box 17 and note Box 5 below)	13. <input checked="" type="checkbox"/> Return Receipt Postcard (MPEP 503)
i. <input type="checkbox"/> Signed statement deleting inventors named in the prior application, see CFR 1.63(d)(2) and 1.33(b)	14. <input checked="" type="checkbox"/> Small Entity Statement [] Statement filed in prior application Status still proper and desired
5. <input type="checkbox"/> Incorporation by Reference (if 4b is checked) The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated therein by reference.	15. <input type="checkbox"/> Certified Copy of Priority Document(s) (if foreign priority is claimed)
6. <input type="checkbox"/> Microfiche Computer Program (Appendix)	16. <input type="checkbox"/> Other:
7. <input type="checkbox"/> Nucleotide/Amino Acid Sequence Submission (all the following are necessary)	
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17. If a CONTINUING APPLICATION, check appropriate box and supply the requisite information: <input type="checkbox"/> continuation <input type="checkbox"/> divisional <input type="checkbox"/> CIP ...of prior application No.: []	

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VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) and 1.27(d)) – SMALL BUSINESS CONCERN

Application No.: not yet assigned
 Filing Date: filed herewith
 Applicant(s): Dan A Steinberg, David W Sherrer and Mindaugas F Dautartas
 Title: **Open Face Optical Fiber Array for Coupling to Integrated Optic Waveguides and Optoelectronic Submounts**

I hereby declare that I am the owner of, or an official empowered to act on behalf of, the entity identified below:

Name of Concern: **ACT MicroDevices, Inc.**
 Address of Concern: **7586 Peppers Ferry Loop
 Radford, VA, 24141**

I hereby declare that the concern identified above qualifies as a small business concern as defined in 37 CFR 1.9(d), for purposes of paying reduced fees to the United States Patent and Trademark Office under section 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention identified above and described in the application for Letters Patent filed herewith.

If the rights held by the concern identified above are not exclusive, each individual, concern or organization having rights to the invention is listed below* and no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37 CFR 1.9(c) if that person made the invention, or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

* NOTE: Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

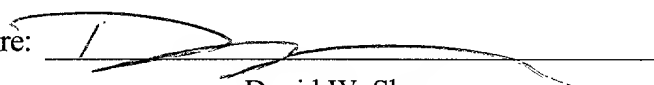
Name:	There is no such concern.	<input type="checkbox"/> Individual
Address:		<input type="checkbox"/> Small Business Concern
		<input type="checkbox"/> Nonprofit Organization

I acknowledge the duty to file, in this application for patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate (37 CFR 1.28(b)).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

ASSIGNEE: ACT MicroDevices, Inc.
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Official Authorized to Act on Behalf of Assignee:

Signature: 
 Name: David W. Sherrer
 Title: President

July 11, 2000
 Date

Patent Application of
5 **Dan A. Steinberg, David W. Sherrer, and Mindaugas F. Dautartas**
for
Open Face Optical Fiber Array for Coupling to Integrated Optic
Waveguides and Optoelectronic Submounts

10 **RELATED APPLICATIONS**

The present application claims the benefit of priority of
copending provisional patent application 60/195,636, filed on
04/07/2000, which is hereby incorporated by reference.

15 **FIELD OF THE INVENTION**

The present invention relates generally to structures for
coupling to integrated optical devices. More particularly, the
present invention relates to an optical fiber array having an
open top face for coupling to integrated optics (IO) chips
20 that have V-grooves for receiving optical fibers. The arrays
of the present invention allow many optical fibers to be
aligned and bonded to an IO chip simultaneously.

25 **BACKGROUND OF THE INVENTION**

Integrated optics (IO) chips have waveguides that typically
must be coupled to optical fibers. Coupling to optical fibers
is difficult because the fibers must be accurately aligned
with the waveguides.

30 In order to provide passive coupling alignment between
optical fibers and IO waveguides, IO chips may have V-grooves
aligned colinearly with the waveguides. An optical fiber
disposed in the V-groove is automatically aligned with the IO
waveguide.

US Pat. 5,123,068 to Hakoun et al. discloses an IO chip having V-grooves for fiber alignment. In the device of Hakoun et al., the optical fibers must be placed in the V-grooves individually, a tedious task.

US Pats. 5,961,683 and 5,557,695 disclose IO chips having V-grooves in a substrate underlying the waveguides. Fibers placed in the V-grooves are aligned with the waveguides.

US Pat. 4,818,059 to Kakii et al. discloses an optical connector having a V-groove chip that is only partially covered by a lid. Exposed V-grooves facilitate the insertion of optical fibers into the V-grooves between the chip and lid.

Individual placement of optical fibers in fiber alignment grooves is time consuming and tedious. It would be an advance in the art to provide a structure and method for placing simultaneously a large number of fibers in fiber alignment grooves.

OBJECTS AND ADVANTAGES OF THE INVENTION

Accordingly, it is a primary object of the present invention to provide an open-face optical fiber array that:

1) can be mated with an integrated optics chips having fiber alignment grooves for accurately locating a large number of optical fiber simultaneously;

2) is simple to construct and can be used for a wide range of optical fiber pitches.

These and other objects and advantages will be apparent upon reading the following description and accompanying drawings.

SUMMARY OF THE INVENTION

These objects and advantages are attained by an optical fiber array having a V-groove chip with V-grooves and an optical fiber disposed in a V-groove. The V-groove chip has a rear portion and a front portion. The front portion has a front face. The optical fiber is bonded (e.g. glued, soldered, or thermo-compression bonded) to the rear portion; the optical fiber is not bonded to the front portion. Preferably, the optical fiber endface is flush with a front face of the V-groove chip.

The array can also have micromachined pits for receiving alignment spheres (e.g. alignment spheres).

A wick stop trench can be disposed between the rear portion and the front portion to control the flow of adhesive (e.g. glue or solder).

The present invention also includes an embodiment where the chip has a rear portion, a middle portion and a bonded front portion. The optical fibers are bonded to the chip in the rear portion and the bonded front portion; the optical fibers are not bonded to the middle portion. In this embodiment, the middle portion mates with the V-grooves of an IO chip.

The present invention also includes a method for bonding optical fibers to an optical device (e.g. IO chip or optoelectronic submount)

DESCRIPTION OF THE FIGURES

Fig. 1 shows a perspective view of the open face fiber array of the present invention.

Fig. 2 shows a second perspective view of the fiber array where the fiber array has a lid.

Fig. 3 shows an integrated optics chip structure that can be coupled to the present optical fiber array.

Fig. 4 shows a perspective view of the fiber array and an IO chip illustrating how the fiber array and IO chip are coupled.

Fig. 5 shows a side view of the fiber array and IO chip coupled.

Fig. 6 shows a perspective view of an optoelectronic submount that can be coupled to the present fiber array.

Fig. 7 shows an IO chip having a smooth surface for contact with the optical fibers.

Figs. 8a-8e illustrate a method for making the optical fiber array of the present invention.

Fig. 8f shows an alternative embodiment of the present invention where the array has an angled front face. The front face is angled forward so that it overhangs the IO waveguide structure.

Fig. 9 shows an alternative embodiment having alignment spheres for providing alignment between the array and IO chip.

Fig. 10 shows an alternative embodiment where the pits for the alignment spheres are large enough to allow active positioning of the fiber array.

Fig. 11 shows an alternative embodiment of the present invention where the optical fiber is bonded to the rear portion and a bonded front portion; the optical fiber is not bonded in a middle portion of the array.

Fig. 12 shows how the array of Fig. 11 is mated with an IO chip.

Fig. 13 shows a cross sectional view of the front portion where the V-groove in the front portion is large so that

is does not fully define the location of the optical fiber.

DETAILED DESCRIPTION

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The present invention provides an open-face optical fiber array for coupling to substrates (e.g. integrated optics (IO) chips) having optical fiber alignment grooves. The open-face array has a V-groove chip with optical fibers disposed in the V-grooves. The V-groove chip has a rear portion where the fibers are bonded in the V-grooves (e.g. with glue), and a front portion where the optical fibers are NOT bonded to the V-grooves. The front portion has a front face that is preferably polished. The optical fibers extend from the rear portion. The optical fibers have endfaces that are preferably flush with the front face. A lid may be disposed on top of the rear portion where the optical fibers are bonded. In use, the array of the present invention is mated with an IO chip so that the unbonded optical fibers are pressed into the V-grooves of the IO chip. Since there is no glue on the optical fibers in the unbonded front portion, the fibers can be accurately aligned in the IO chip V-grooves

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Fig. 1 shows a perspective view of an open face optical fiber array according to the present invention. The open face fiber array has optical fibers **20** disposed in precision V-grooves **22** of a V-groove chip **23**. For clarity, one V-groove in the array does not have a fiber. The array has a rear portion **24** and a front portion **26**. The front and rear portions may be the same or different lengths (in the direction of the V-grooves). In the rear portion **24**, the optical fibers are bonded to the V-groove chip **23**; in the front portion **26**, the optical fibers are necessarily NOT bonded to the V-groove chip **23**. In the present speification, the rear portion **24** is defined as a

region where the fibers are bonded to the chip **23**. The front portion is defined as a region where the optical fibers are not bonded to the chip **23**. Preferably, the optical fibers **20** are bonded to the rear portion **24** with glue **28**. Optionally, the optical fibers can be bonded to the rear portion **24** with solder or other materials or by using other techniques (e.g. thermo-compression bonding).

In a preferred embodiment of the invention where glue is used to bond the optical fibers **20**, a wick stop trench **30** is provided. The wick stop trench **30** separates the rear portion **24** and the front portion **26**. The wick stop trench serves to prevent the flow of liquid glue by capillary action to the front portion **26**. The wick stop trench is described in copending patent application **09/526,922**, which is hereby incorporated by reference. The wick stop trench is optional, but preferred, in embodiments where flowable glues (e.g. UV- or heat-curable epoxy) or liquid solders are used to bond the optical fibers to the chip **23**.

If a wick stop trench is not used, then highly viscous glues with low capillary flow can be used to bond the optical fibers to the chip. Viscous glues tend to not flow to the front portion **26** from the rear portion **24**.

In an alternative embodiment of the present invention, thermo-compression bonding is used to bond the optical fibers to the rear portion. For example, US pats 5,389,193 and 5,178,319 disclose useful methods of aluminum thermo-compression bonding for bonding optical fibers to V-grooves. In the case where aluminum thermo-compression is used, it is preferable to only deposit aluminum in the rear portion of the V-groove chip. In this way, the optical fiber is only bonded to the rear portion.

Fig. 2 shows another perspective view of the open face fiber array. The array in **Fig. 2** has an optional lid **32** covering the rear portion **24**. The lid **32** is preferably glued to the optical fibers and chip **23**. The array has a front face **34** at the edge of the front portion **26**. The optical fibers **20** have fiber endfaces **36**. The endfaces can be cleaved or polished; preferably, the endfaces **36** are polished. Also preferably, the fiber endfaces **36** are flush with the front face **34**. In a particularly preferred embodiment, the front face **34** and fiber endfaces **36** are polished in the same polishing step. This assures that the fiber endfaces **36** and the front face **34** are flush.

Fig. 3 shows a perspective view of an integrated optics chip structure that can be coupled to the optical fiber arrays of the present invention. The integrated optics (IO) chip has waveguides **38** disposed in a cladding material **40**. The waveguides and cladding are disposed on a substrate chip **42** (e.g. made of silicon). The waveguides **38** and cladding can be made of silicon, polymer materials or silica. V-grooves **44** for aligning optical fibers are disposed in alignment with the waveguides **38**. The waveguides **38** intersect a sidewall **46** that is smooth enough for optical coupling to the waveguides. The V-grooves **44** and waveguides **38** are separated by a cut groove **48**. The cut groove may be a dicing saw cut groove, for example. The use of a dicing saw cut groove in IO chips is known in the art.

The cut groove **48** preferably has a width less than 5-6 times the diameter of the optical fiber so that bending of the optical fiber in the region of the cut groove is minimized. For example, for 125 micron diameter optical fibers, the cut groove **48** should have a width less than about 700 microns.

More preferably, the cut groove has a width less than about 300 or 150 microns.

It is noted that the present optical fiber arrays can be used to couple to IO chips that do not have cladding material **40** disposed on the waveguides. For example, the waveguides can be made of polymer material disposed directly on the substrate chip or a cladding layer.

Fig. 4 illustrates how the optical fiber arrays of the present invention mate with the IO chip shown in **Fig. 3**. In the present invention, the optical fibers **20** in the array are pressed into the V-grooves **44** of the IO chip. Since the optical fibers **20** are not bonded to the front portion **26**, the fibers can shift slightly to fit perfectly within the IO chip v-grooves **44**. It is important to note that only the front portion **26** is mated with the IO chip. Also, since the fibers are not bonded in the front portion **26**, there is no danger of residual, hardened glue interfering with contact between the fibers **20** and the IO chip V-grooves **44**. This is an important consideration because even a very thin film (e.g 1-3 microns) of glue residue on top of the fibers **20** can significantly harm fiber-waveguide alignment.

After the optical fibers **20** are disposed in the V-grooves **44**, glue or solder is applied to bond the fibers to the IO chip. Preferably, the optical fiber endfaces **36** are butted against the waveguides **38**. The interface between the optical fibers and the waveguides can be oriented at a nonperpendicular angle with respect to the optical fibers and waveguides to reduce backreflections. In this case, the front face **34** and the cut groove **48** should be cut at precisely matching angles.

Fig. 5 shows a side view of the present fiber array coupled to an IO chip.

The fiber arrays are also useful for coupling optical fibers to optoelectronic submounts. The optoelectronic submount can have a laser array or photodetector array disposed adjacent to V-grooves. **Fig. 6** shows an exemplary optoelectronic submount that can be coupled to the present fiber array. The submount has a submount chip **52** with pedestals **54** for alignment of an optoelectronic chip **56**. The submount chip also has V-grooves **58** for positioning optical fibers. The submount chip may also have a cut groove analogous to cut groove **48** in the IO chip of **Fig. 3**. However, it is generally preferable for the submount chip to not have a cut groove (i.e., analogous to cut groove **48**). This is because a cut groove can contribute to fiber misalignment. It is also noted that an IO chip can be substituted for the optoelectronic chip **56**.

Fig. 7 shows an alternative embodiment where the IO chip does not have V-grooves **44**. Instead, surface **60** is smooth. The fiber array of the present invention can be coupled to this structure by pressing the optical fibers against the smooth surface **60**. After the fibers are actively aligned, the optical fibers are bonded to the smooth surface **60** using glue or solder.

Figs. 8a-8e illustrate a method for making the optical fiber array of the present invention. The steps for making the fiber array are as follows:

Fig. 8a: Optical fibers are disposed in the v-grooves of the V-groove chip.

Fig. 8b: A lid **32** is placed on top of the optical fibers on the rear portion **24**. Glue is applied to the rear portion to adhere the lid **32**, fibers and v-groove chip.

Fig. 8c: A temporary holding plate **66** is pressed against the front portion **26**. The plate is not glued to the fibers. The plate **66** may be pressed against the fibers using a metal spring or clamp. The plate **66** may have V-grooves or may be flat.

Fig. 8d: The front portion and optical fiber **20** (and, optionally the plate **66**) are lapped and polished to plane **68**. The plane **68** can be perpendicular to the optical fibers, or set at an angle to the optical fibers. Plane **68** may be set at an angle in order to reduce backreflections. This is particularly useful in applications where the cut groove **48** in the IO chip is cut at an angle. In this case, angles of the plane **68** and cut groove **48** should match.

Fig. 8e: The plate is removed. Optical fibers are not bonded to the V-groove chip in the front portion **26**. The optical fibers have polished endfaces that are accurately flush with the front face of the V-groove chip.

Alternatively, the lid **32** is removed after the fibers are glued. The lid **32** can have a nonstick (e.g. PTFE) coating to prevent glue from bonding the lid **32** to the array.

Fig. 8f shows a side view of an array with an angled front face **51** mated with an IO chip. In this specific embodiment, the front face **51** is angled forward so that it overhangs the waveguide **38**. This is preferable because the angled waveguide **38** tends to push the optical fiber into the V-groove **22**. The fiber array and waveguide can be angled at about 5-20 degrees,

for example, to reduce backreflections. It is noted that the fiber array and waveguide can be angled 'backward' as well, so that the waveguide 'overhangs' the optical fiber 20.

5 **Fig. 9** shows an embodiment where the optical fiber array has pits 70 for receiving alignment spheres 72 (e.g. ball lenses) that mate with pits 74 on the integrated optics chip. The optical fibers 20 are in contact with the smooth surface 60. Alternatively, the pits 70 74 are used in combination with V-grooves 44 in the IO chip.

10 **Fig. 10** shows another embodiment where the pits 70 are made wider than the alignment spheres 72 so that the optical fiber array can move slightly on the smooth surface 60 (alternatively, pits 74 are made wider than the alignment spheres). Of course, this feature is only applicable if the IO chip has the smooth surface 60. By allowing the optical fiber array to move slightly, both active and passive alignment can be provided; passive alignment is provided by mating the pits and alignment spheres, and active alignment is allowed because the alignment spheres can move slightly (e.g. 10-20 microns) within the pits.

15 **Fig. 11** shows another aspect of the present invention where the array has a second wick stop trench 80. The first wick stop trench 30 and second wick stop trench 80 divide the fiber array into three parts: the rear portion 24, a middle portion 82, and a bonded front portion 84. The fibers 20 are bonded to the rear portion 24 and the bonded front portion 84. The fibers are not bonded to the middle portion 82. Preferably, the fibers are in close contact with the V-grooves in the middle portion; the fibers must not be buckled or bent in the middle portion 82. Also, it is noted that the bonded front portion 84 is relatively short (preferably less than 1 mm

long). The bonded front portion **84** must be shorter than the width of the cut groove **48** in the IO chip.

The embodiment of **Fig. 11** solves a potential problem with the array of **Figs. 1** and **2**. In the arrays of **Figs. 1** and **2**, the optical fiber can bend slightly in the area of the cut groove **48** thereby causing misalignment between the optical fiber and IO waveguide **38**. The fiber can bend slightly in the area of the cut groove **48** because the fiber is not bonded to the V-groove **22**.

By comparison, the optical fiber **20** cannot bend in the area of the cut groove **48** when the array of **Fig. 11** is used. This is because the optical fiber **20** is glued to the bonded front portion **84**.

Fig. 12 shows a side view of the array of **Fig. 11** mated with an IO chip. The bonded front portion **84** is shorter than the cut groove **48**. Since the optical fibers are bonded to the bonded front portion **84**, the fibers cannot become misaligned. Also, the optical fibers are not bonded to the middle portion **82** until after the array is mated with the IO chip. This allows the fibers to seat properly in the V-grooves **44** of the IO chip.

In one embodiment, the V-grooves **22** are wider in the front portion **26** than the rear portion **24**. In this embodiment, the position of the optical fibers **20** is not fully determined by the V-grooves in the front portion **26**. This is advantageous in some applications because it allows the IO chip V-grooves **44** (or, equivalently, the submount chip V-grooves **58**) to determine the positions of the optical fibers **20**. **Fig. 13**, for example, shows a cross sectional view of an optical fiber disposed in a V-groove **90** that does not fully determine the

position of the the optical fiber. The fiber can move left-right in the V-groove 90 because the optical fiber only contacts a flat bottom surface 92. It is noted, however, that the V-groove chip must be able to press the optical fiber into the V-groove 44 of the IO chip. For example, the V-groove 90 has the flat bottom surface 92 that can press the optical fiber into the IO chip V-groove 44.

It is noted that if the fiber array is mated with an IO chip (or submount) having a smooth surface 60 (shown in Fig. 7), then the V-grooves 22 in the front portion 26 must fully define the optical fiber position.

Preferably, the position of the optical fiber in the rear portion is fully defined by the V-grooves, but this is optional.

In the present invention, the V-groove chip is preferably made from silicon using anisotropic etching techniques. Other materials can also be used for the V-groove chip such as glass, ceramics or plastics. In these cases, the V-grooves can be cut using a diamond saw, or the V-groove chips can be molded. The wick stop trenches can be anywhere from 50 microns to 1000 microns wide. The best width for the wick stop trenches depends upon the capillary flow characteristics of the glues or solders used. Also, the wick stop trenches should be deeper than the V-grooves.

It will be clear to one skilled in the art that the above embodiment may be altered in many ways without departing from the scope of the invention. Accordingly, the scope of the invention should be determined by the following claims and their legal equivalents.

CLAIMS

What is claimed is:

1. An optical fiber array apparatus for providing optical
5 connections to an optical device, comprising:

a) a V-groove chip having a V-groove, a rear portion, a
front portion, and a front face opposite the rear
portion, and

10 b) an optical fiber disposed in the V-groove, wherein:

1) the optical fiber is bonded to the rear portion of
the chip,

2) the optical fiber is not bonded to the front
portion of the chip, and

15 3) wherein the optical fiber extends from the rear
portion.

2. The apparatus of claim 1 wherein the optical fiber has
an endface located within 1 millimeter of the front
face.

3. The apparatus of claim 1 wherein the V-groove chip has
a wick stop trench between the rear portion and the
front portion.

25 4. The apparatus of claim 1 further comprising a lid
disposed on top of the optical fibers in the rear
portion.

30 5. The apparatus of claim 1 wherein the optical fiber has
an endface that is flush with the front face.

6. The apparatus of claim 1 wherein the front portion is
1-10 millimeters long.

7. The apparatus of claim 1 wherein the rear portion is 0.2-5 millimeters long.

8. The apparatus of claim 1 wherein the front portion has pits for receiving alignment spheres.

9. The apparatus of claim 1 wherein the front face is angled nonperpendicularly with respect to the optical fiber.

10. The apparatus of claim 9 wherein the front face is angled forward.

11. The apparatus of claim 1 wherein the V-grooves are large in the front portion so that a location of an optical fiber is not fully determined by the V-groove in the front portion.

12. The apparatus of claim 11 wherein the V-groove in the front portion has a flat bottom surface.

13. An optical fiber array apparatus for providing optical connections to an optical device, comprising:

a) a V-groove chip having a V-groove, a rear portion, a middle portion, a bonded front portion, and a front face opposite the rear portion, and

b) an optical fiber disposed in the V-groove, wherein:

1) the optical fiber is bonded to the rear portion of the chip,

2) the optical fiber is not bonded to the middle portion of the chip,

- 3) the optical fiber is bonded to the bonded front portion of the chip, and
- 4) wherein the optical fiber extends from the rear portion.

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14. The apparatus of claim 13 wherein the optical fiber has an endface located within 1 millimeter of the front face.

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15. The apparatus of claim 13 wherein the V-groove chip has a wick stop trench between the rear portion and the front portion.

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16. The apparatus of claim 13 wherein the V-groove chip has a wick stop trench between the middle portion and the bonded front portion.

17. The apparatus of claim 13 further comprising a lid disposed on top of the optical fibers in the rear portion.

18. The apparatus of claim 13 wherein the optical fiber has an endface that is flush with the front face.

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19. The apparatus of claim 13 wherein the bonded front portion is 0.2-2 millimeters long.

20. The apparatus of claim 13 wherein the rear portion is 0.2-5 millimeters long.

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21. The apparatus of claim 13 wherein the front portion has pits for receiving alignment spheres.

22. The apparatus of claim 13 wherein the front face is angled nonperpendicularly with respect to the optical fiber.

5 23. A method for coupling an optical fiber to an optical device disposed on a substrate, comprising the steps of:

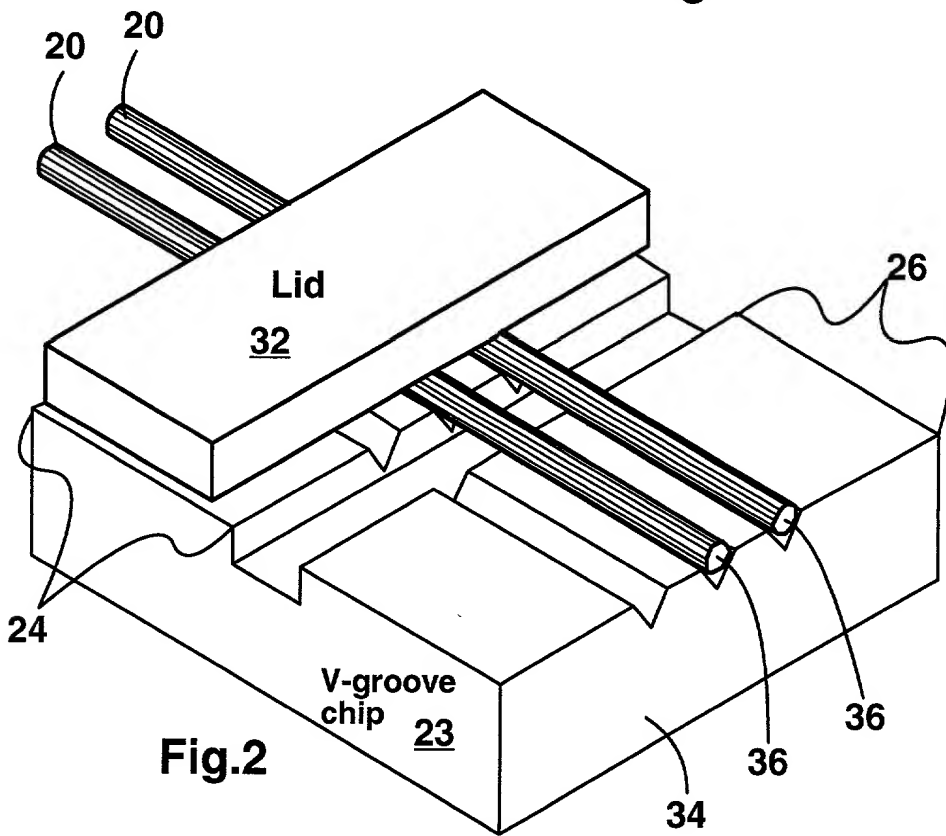
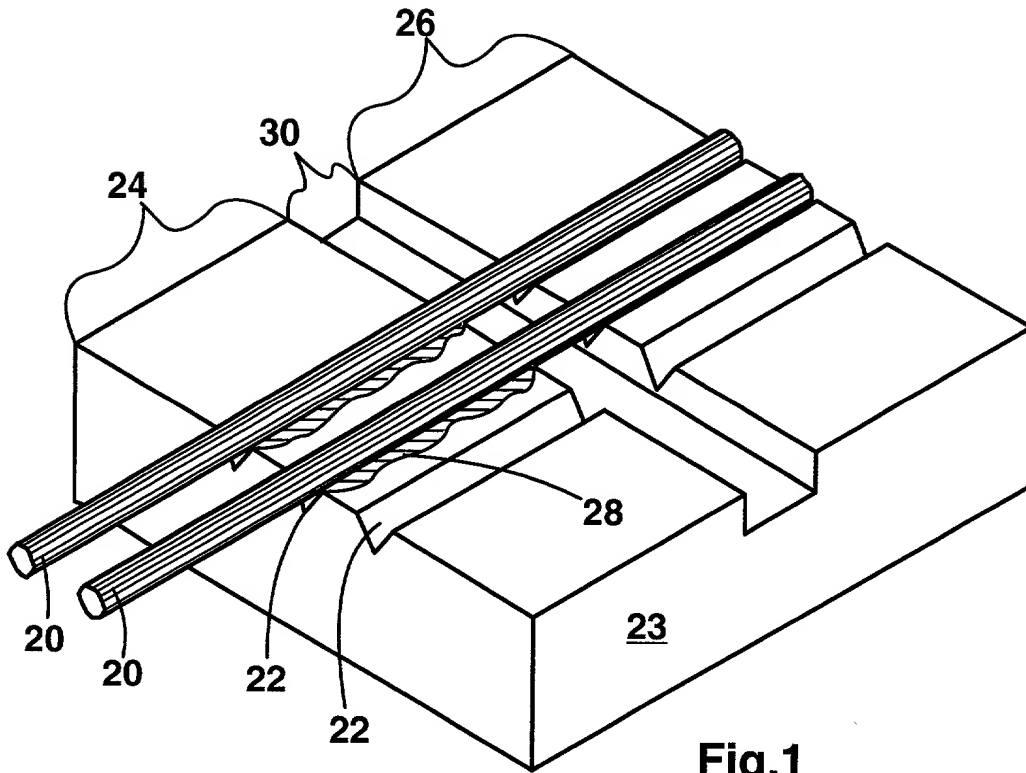
- 10 a) bonding the optical fiber to only a rear portion of a V-groove chip having a rear portion and a front portion;
b) bonding the optical fiber and front portion of the V-groove chip to the substrate so that the optical fiber is aligned with the optical device.

24. The method of claim 23 further comprising the step of disposing the optical fiber in a V-groove in the substrate, wherein the substrate V-groove is aligned with the optical device.

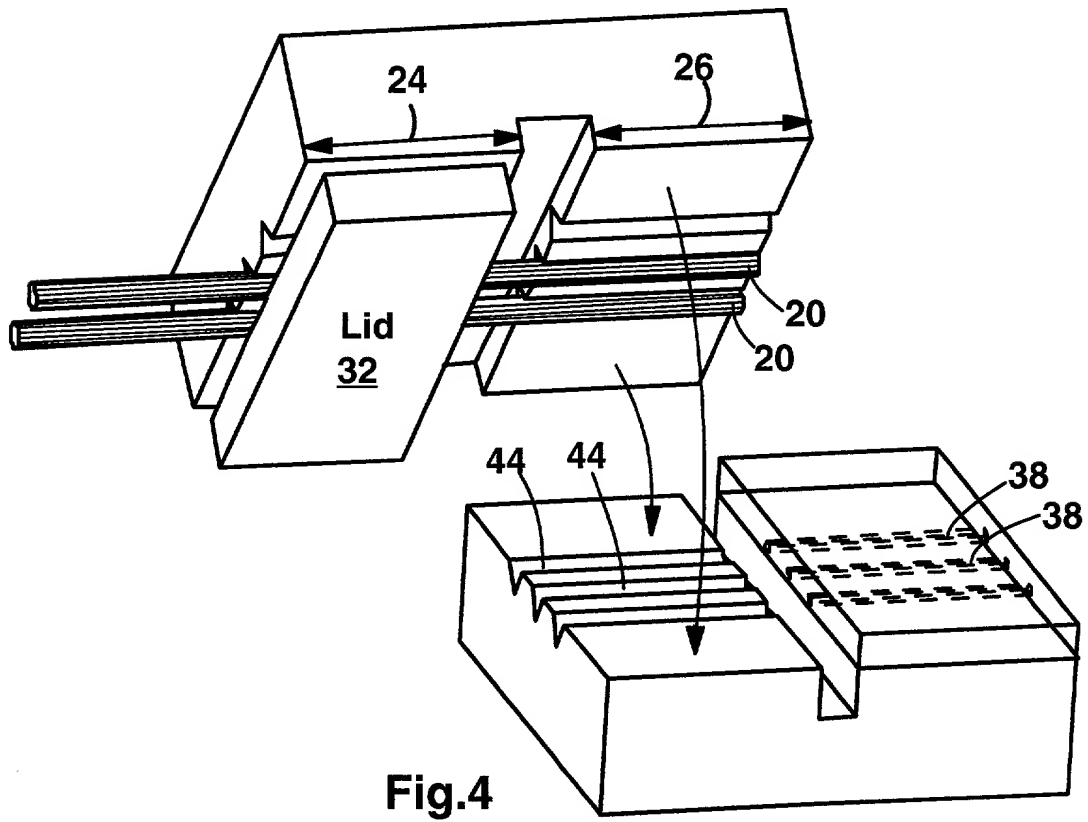
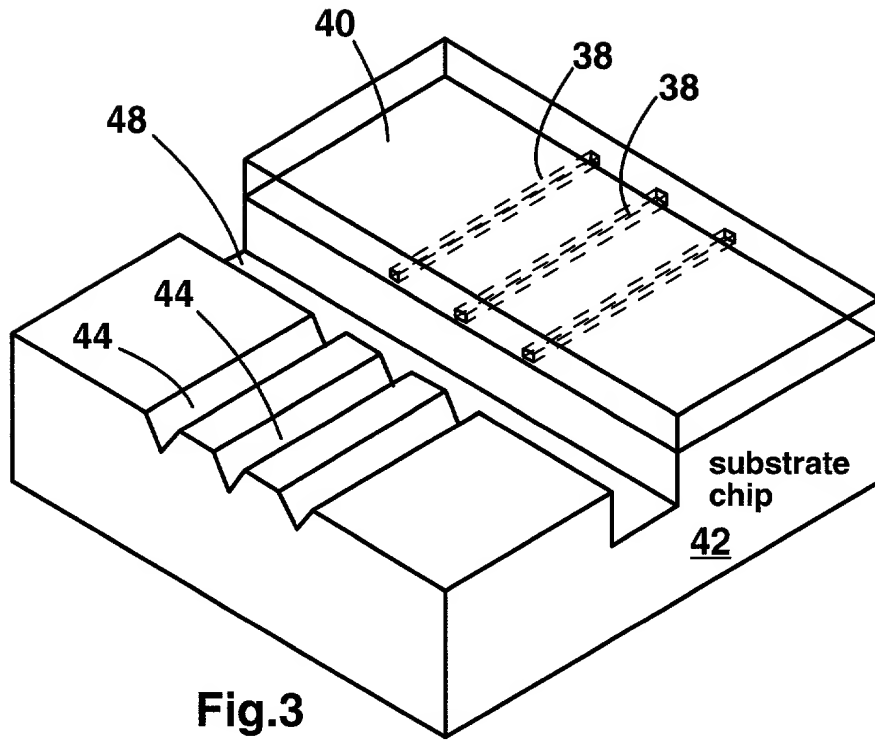
**Open Face Optical Fiber Array for Coupling to Integrated Optic
Waveguides and Optoelectronic Submounts**

ABSTRACT OF THE DISCLOSURE

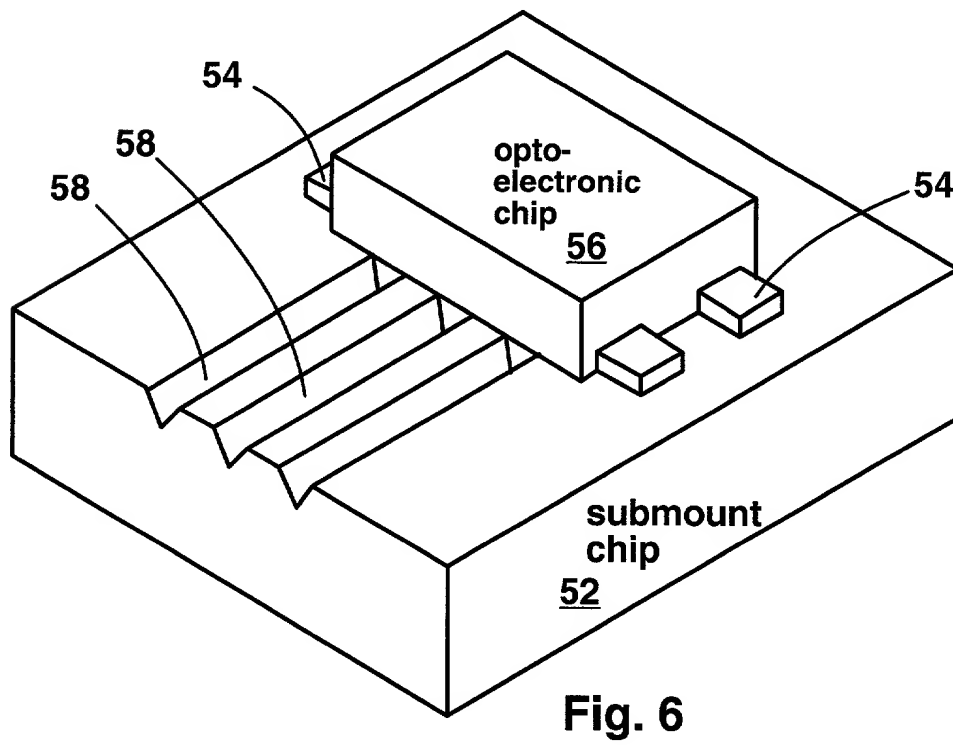
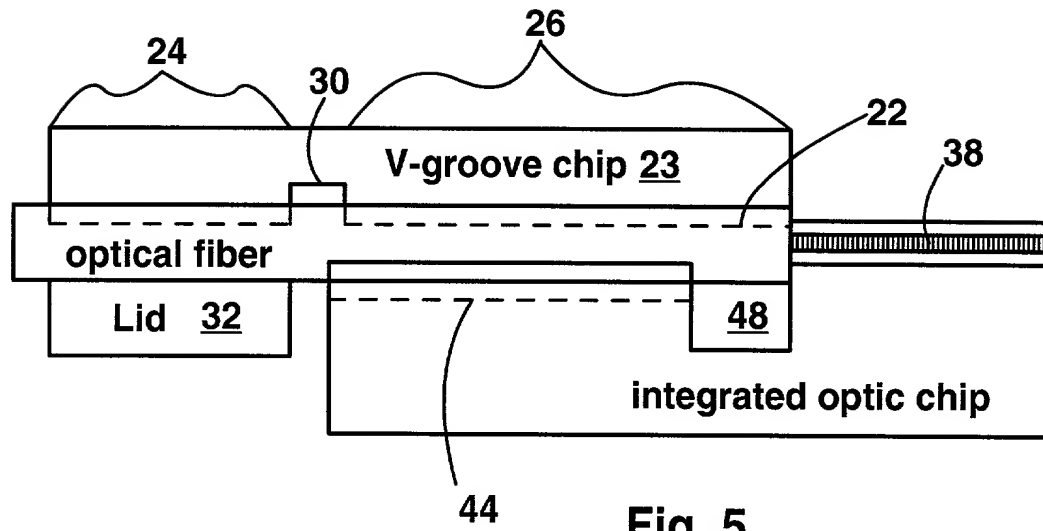
An optical fiber array having a V-groove chip with a front portion and a rear portion. The optical fibers are disposed in the V-grooves. The optical fibers are bonded (e.g. glued) to the V-groove chip in the rear portion of the chip. The optical fibers are not bonded to the front portion of the chip. Preferably, the optical fibers have endfaces that are flush with a front face of the chip. The optical fibers extend from the rear portion. In use, the optical fiber array is pressed against V-grooves of an integrated optics chip or optoelectronic submount. Since the optical fibers are not bonded to the front portion, they can move slightly to fit precisely into V-grooves of the IO chip or submount. Hence, optical fiber alignment is improved. Also, there is no danger of residual adhesive preventing close contact between the optical fibers and IO chip.



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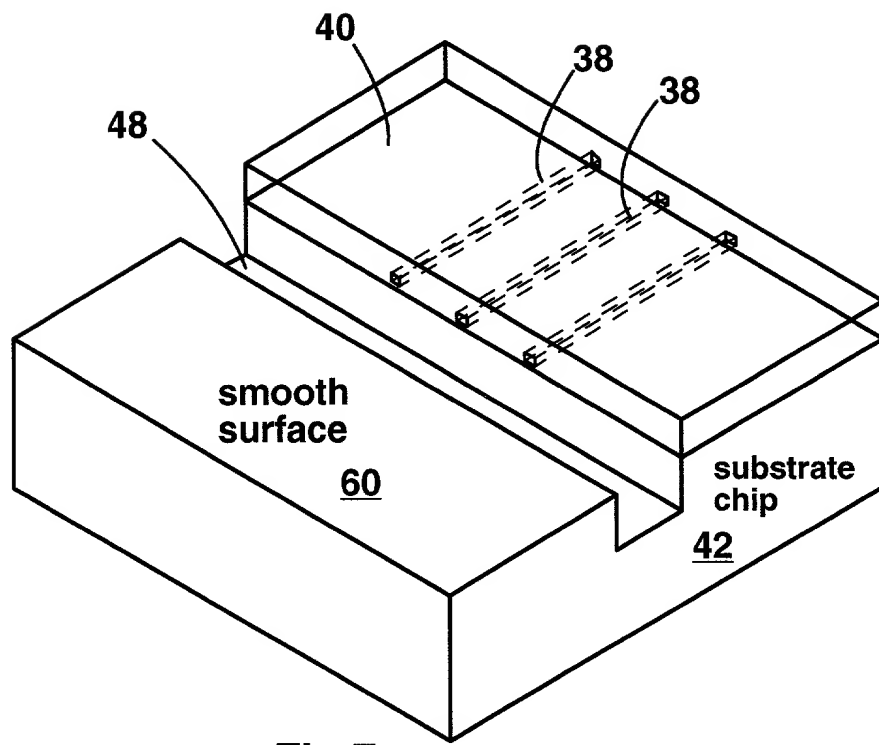
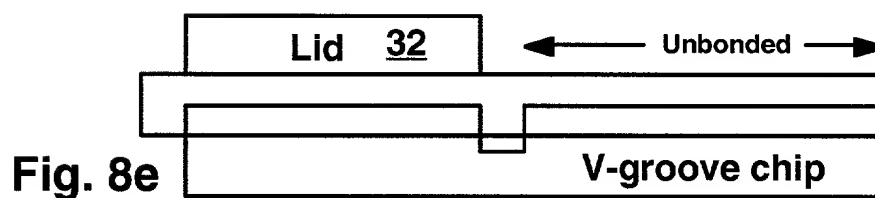
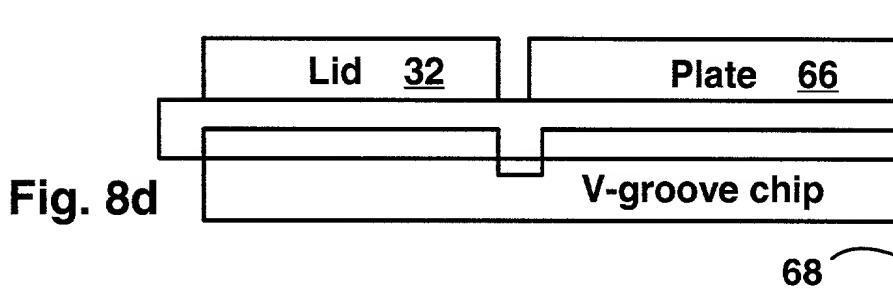
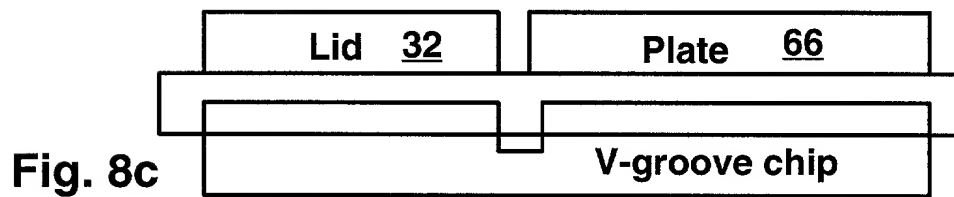
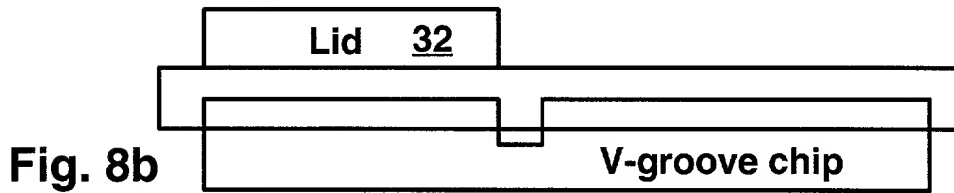
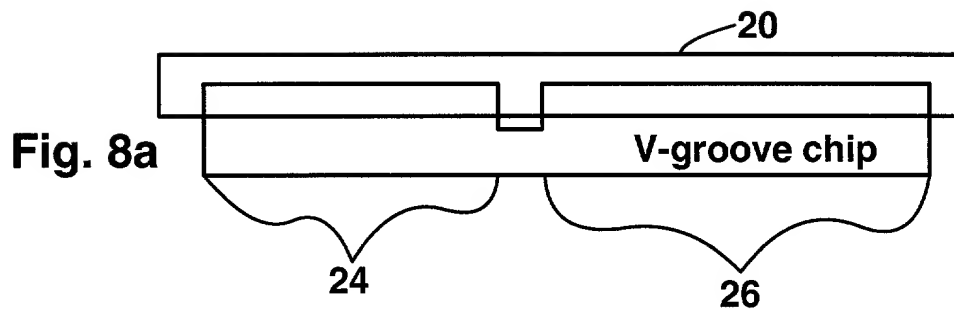
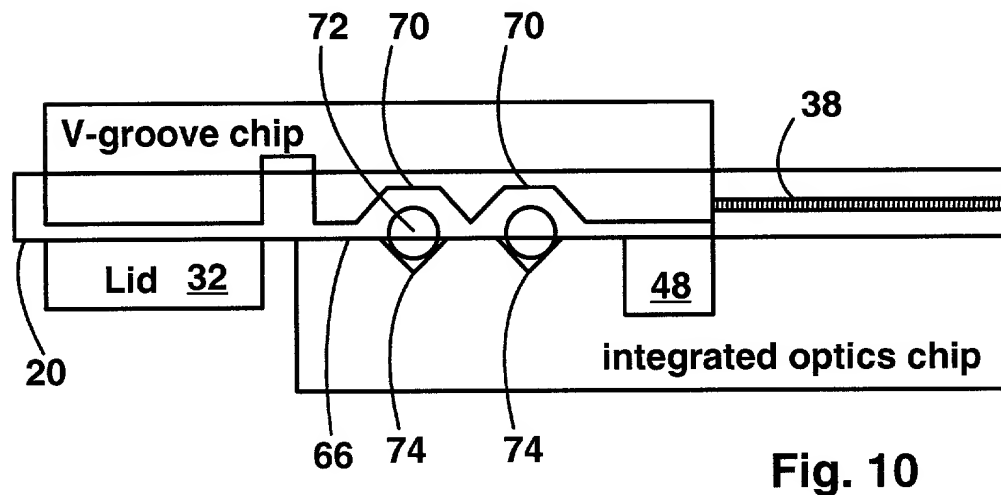
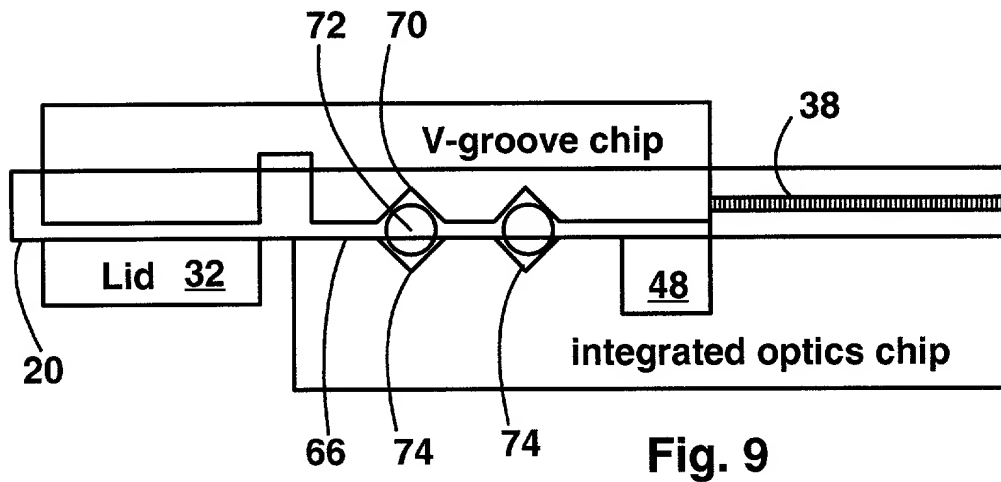
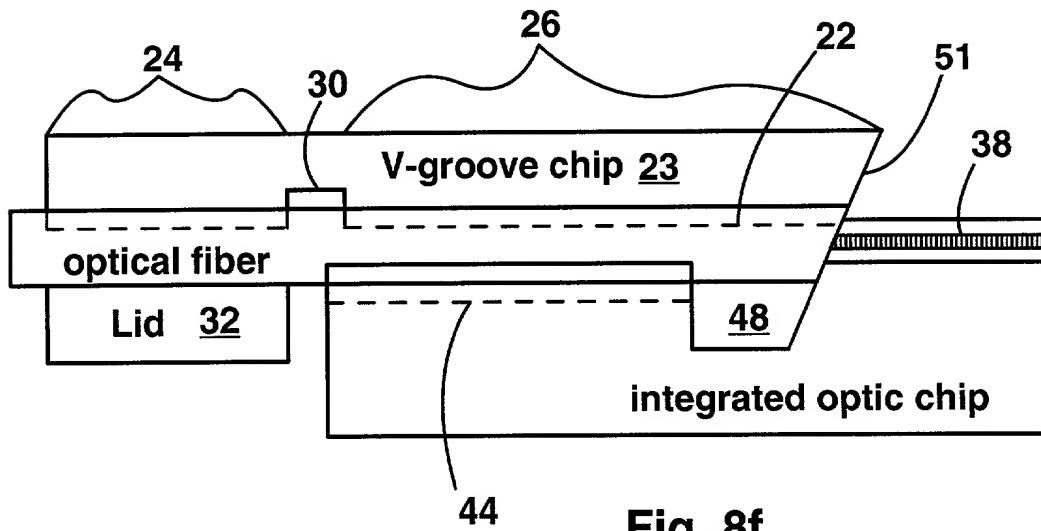


Fig.7



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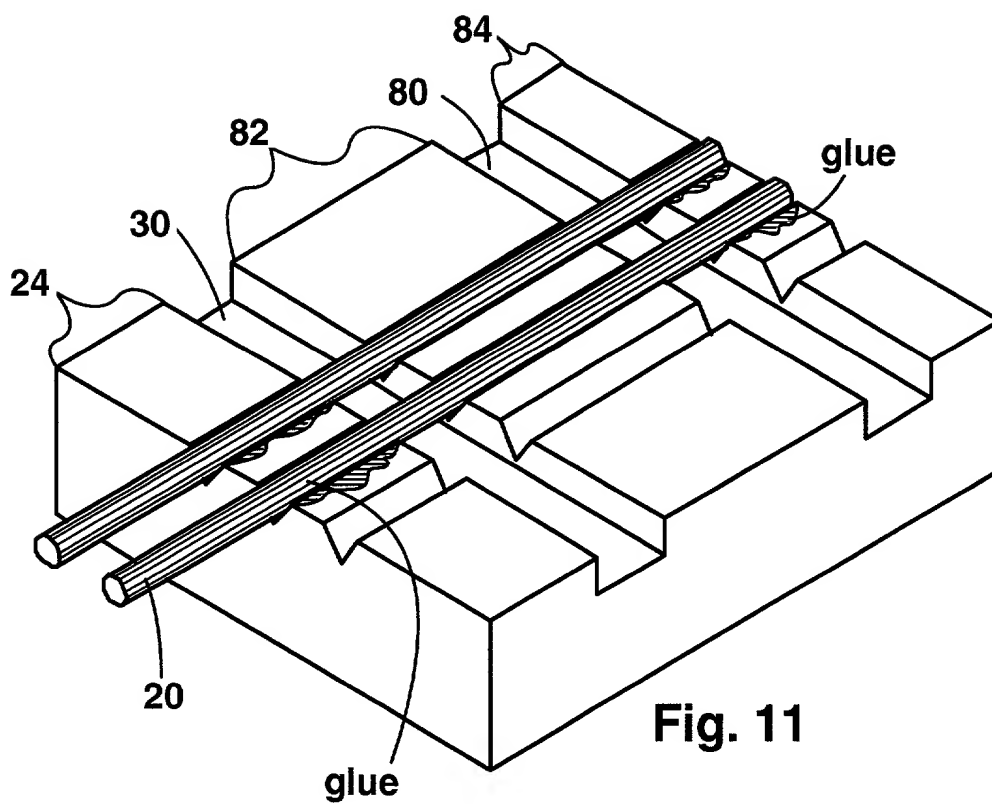


Fig. 11

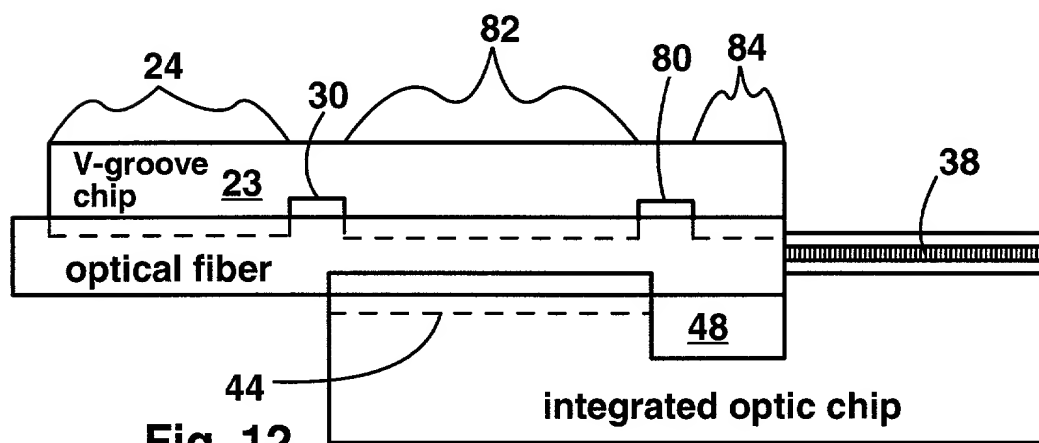


Fig. 12

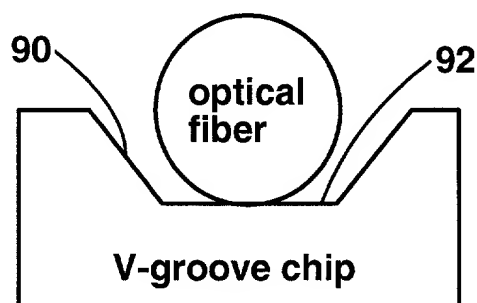


Fig. 13

Declaration for Patent Application and Power of Attorney

As a below named inventor, I hereby declare that my residence, post office address, and citizenship are as stated below next to my name, and that I believe I am the original, first and sole inventor (if only one is listed) or an original, first and joint inventor (if plural names are listed) of the subject matter which is claimed and for which a patent is sought on the invention described in the attached specification entitled **Open Face Optical Fiber Array for Coupling to Integrated Optic Waveguides and Optoelectronic Submounts**

First or Sole Inventor:	Full name:	DAN A STEINBERG	Citizenship:	United States
	Residence:	7586 Peppers Ferry Loop		
	Postal Address:	Radford, VA, 24141		
Second Joint Inventor (if any):	Full name:	DAVID W SHERRER	Citizenship:	United States
	Residence:	7586 Peppers Ferry Loop		
	Postal Address:	Radford, VA, 24141		
Third Joint Inventor (if any):	Full name:	MINDAUGAS F DAUTARTAS	Citizenship:	United States
	Residence:	7586 Peppers Ferry Loop		
	Postal Address:	Radford, VA, 24141		

I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a). I claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed.

PRIOR FOREIGN APPLICATION(S)

Country	Application Number	Date of Filing	Priority Claimed Under 35 U.S.C. §119
NONE			<input type="checkbox"/> Yes <input type="checkbox"/> No

I claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

PRIOR U. S. APPLICATION(S)

Application No.	Filing Date	Status
60/195,636	04/07/2000	<input checked="" type="checkbox"/> Provisional <input type="checkbox"/> Patented <input type="checkbox"/> Pending <input type="checkbox"/> Regular

I hereby appoint Dan A Steinberg Reg No. 45,129 as my agent with full power of substitution to prosecute this application and transact all business in the United States Patent and Trademark Office connected therewith. Direct all correspondence to:

Dan Steinberg
 ACT MicroDevices, Inc.
 7586 Peppers Ferry Loop
 Radford, VA, 24141
 Telephone: 540-639-1986, ext. 26
 Fax: 540-639-2246.

The attorney docket number for this case is: **ACT-121.**

I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both under Title 18, §1001 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

INVENTOR SIGNATURE(S)

Dan Steinberg
 NAME

July 11, 2000
 DATE

[Signature]
 NAME

7/11/00
 DATE

Mindaugas F. Dautartas
 NAME

7/11/00
 DATE

POWER OF ATTORNEY BY ASSIGNEE

The undersigned assignee of the entire interest in the attached application for Letters Patent for the invention entitled:

Open Face Optical Fiber Array for Coupling to Integrated Optic Waveguides and Optoelectronic Submounts

by virtue of Assignment recorded concurrently herewith hereby appoints Dan A. Steinberg, Reg. No 45,129 as its agent to prosecute the attached application and to transact all business in the Patent and Trademark Office connected therewith, said appointment to be to the exclusion of the inventor(s) and their attorney(s) in accordance with the provisions of Rule 32 of the Patent Office Rules of Practice.

Please direct all communication relative to said application to the following correspondence address:

Dan Steinberg
ACT MicroDevices, Inc.
7586 Peppers Ferry Loop
Radford, VA, 24141
Telephone: 540-639-1986, ext 26
Facsimile: 540-639-2246

I am duly authorized to sign this instrument on behalf of assignee corporation. I hereby declare that, to the best of my knowledge and belief, title is in the assignee herein, and I affirm review of the Assignment document concurrently submitted and believe that the attached application has been assigned to assignee herein and that assignee therefore has the right to make this Power of Attorney and Exclusion of Inventor(s).

I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

ASSIGNEE: ACT MicroDevices, Inc.

ACT MicroDevices, Inc.
7586 Peppers Ferry Loop
Radford, VA, 24141

Official Authorized to Act on Behalf of Assignee:

Signature: David Sherrer
Name: David Sherrer
Title: President

July 11, 2000
Date